

SOME NUCLEI OF CLOUDY CONDENSATION.

By Dr. J. AITKEN.

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By means of an improved apparatus for producing a series of definite expansions of a given volume of saturated air, the author studied the cloud-producing qualities of dust particles of different sizes obtained in various ways. After the air was cleared of the largest particles by one or more applications of a 2 per cent expansion, cloud-producing particles of smaller sizes were removed in succession by expansions 4 per cent, 6 per cent, 8 per cent, and so on up to 20 per cent, if necessary. The particles were produced by such means as flames, electric sparks, chemical action, and heating of solid substances; and the general conclusion was that in no expansion lower than 25 per cent was there any evidence of electric ions being by themselves efficient nuclei for cloudy condensation. The view that the nuclei of cloudy condensation produced by heat are ions discharged at high temperatures is not supported, since such nuclei are produced at much lower temperatures than that at which ionic discharge from heated bodies occurs; and even at this higher temperature spectroscopic examination shows that some chemical or disintegrating action takes place along with the discharge of the ions.

CONDENSATION AND EVAPORATION OF GAS MOLECULES.

By I. LANGMUIR.

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Previous work by the author gave evidence that atoms of tungsten, molybdenum, or platinum vapors, striking a clean, dry glass surface in high vacuum, are condensed as solids at the first collision with the surface. Similar evidence was obtained from a study of chemical reactions in gases at low pressures. It was concluded that in general, when gas molecules strike a surface, the majority of them do not rebound from the surface by elastic collisions, but are held by cohesive forces until they evaporate from the surface. In this way a theory of adsorption was developed which has been thoroughly confirmed by later experiments, viz, the amount of material adsorbed depends on a kinetic equilibrium between the rate of condensation and the rate of evaporation from the surface. Practically every molecule striking the surface condenses (independently of the temperature), while the rate of evaporation depends on the temperature and is proportional to the fraction of the surface covered by the adsorbed material. R. W. Wood's experiments on mercury atoms impinging on a glass plate at definite temperatures are referred to and discussed, following which comes a review of Wood's experiments on a stream of cadmium atoms, which stream on striking walls of a well-exhausted glass bulb does not form a visible deposit unless the glass is at a temperature below about $-90^{\circ}\text{C}.$, but when started the deposit continues to grow in thickness even after it is warmed to room temperature. Wood concludes that nearly all atoms of cadmium are reflected from surfaces other than cadmium if the initial temperature is above $-90^{\circ}\text{C}.$ The present author criticizes this reflection theory and proposes as a better alternative the condensation-

evaporation theory, and, to determine definitely which of the two theories correspond best with the facts, he has repeated Wood's experiments under modified conditions which are described at some length. The experiments prove that single cadmium atoms actually evaporate off of a glass surface at temperatures below room temperature, although they do not do so at an appreciable rate from a cadmium surface. The condensation-evaporation theory thus verified affords a very satisfactory explanation of Moser's breath-figures on glass and the peculiar effect observed in the formation of frost crystals on window-panes. The author opines his theory to be capable of extension to the whole subject of nucleus formations, including the crystallization of subcooled liquids.—*H. H. Ho[lgson].*

COMPUTATION AND MEASUREMENT OF THE COMPLEX MOLECULES OF SOME VAPOURS, ACCORDING TO THE NEW CONDENSATION THEORY.¹

By L. ANDRÉN.

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* * * The series of experiments were conducted in the absence of any electric field; with electric field up to 330 volts/cm; by increasing the never-absent radioactive radiations of the atmosphere and earth with the aid of pitchblende and of weak and strong radium preparations, first with water vapor and air. The experiments with CO_2 as gas gave much the same results. When the gas was hydrogen the results differed from those previously obtained when the small [spherical expansion chamber] was used, but agreed again when the large sphere [260 cu. cm.] was applied; Wilson's condensation chamber, it is pointed out, was still smaller than the author's small [60 cu. cm.] sphere. Alcohol was tried mixed with air and with hydrogen; benzene only in air mixtures. The general conclusion drawn is that the ordinary condensation by expansion depends mainly on the formation of electrically neutral complex vapor molecules and their size and surface tension, and is hence independent of the gas containing the vapors, while the electric carriers (ions) play only a secondary part. The formation of nonelectric nuclei is a function of the vapor; the presence of traces of foreign vapors has no influence, provided chemical reactions (due to radiations) be excluded; the nuclei consist hence of complex polymerized vapor molecules. In addition to these nonelectric nuclei there are electric carriers of both polarities, due to the radiations (terrestrial and atmospheric); they make up perhaps 1 per cent of the whole nuclei and consist predominantly also of vapor molecules. In size the nuclei differ with the nature of the liquid (vapor); but there is no discontinuity between the mists and the drops of a vapor, and the two types of condensation can not be differentiated by definite expansion values. The electric carriers are always the largest nuclei; their number naturally depends also on the gas; their number, 900 (no external field), would correspond to the 0.4 carriers per second per cu. cm. assumed to account for the very small residual conductivity of the air. There are, further, when the supersaturation degree is 5 or more, some very large nonelectric nuclei (0.1 per cent of total number) due to the chemical reactions caused by the terrestrial radiations (H_2O_2 , O_3 , etc.). By far the greater number of nonelectric nuclei are, however, small in size and consist of complexes of only a few (2 or 3) molecules; their number, deter-

¹ *Proceed., Nat'l Acad. Sci.*, March, 1917, 3:141-147.¹ *Ann. d. Physik*, Feb. 5, 1917, 521:1-71.

mined for each vapor at ordinary temperature, is: water 1.9×10^{-11} , ethyl alcohol 2.5×10^{-11} , benzene 0.8×10^{-11} per cent of the total vapor molecules present, which would correspond to about 100,000,340,000,190,000 molecules per cu. cm. These nonelectric molecules are characteristic for each vapor. Exposure of the vapor-gas mixtures to β and γ radiations, further increases the size of the nuclei, and thus the numbers of molecules per nucleus, to 8 for water and 6 for alcohol; and increases also in particular their number very much, in accordance with the radiation intensity. Lenard's theory supplements Kelvin's theory by adding a term depending on the ratio of the portion of the drop surface from which evaporation can take place, and on the surface tension which varies with the radius and the thickness of the liquid shell. It also differs from J. J. Thomson's theory in so far as with increasing expansion a supersaturation is said to be reached at which all the nuclei are condensed; the total number of nuclei in water vapor (no external field) seems to be limited to 10^5 , as stated.—H. B[orns].

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A NEW EVAPORATION FORMULA.¹

By R. E. HORTON.

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In 1802 Dalton deduced the formula $E = C(V - v)$, where E is the rate of evaporation from a liquid surface, V the vapor pressure corresponding with the temperature of the liquid, v the vapor pressure existing in the atmosphere at the time and C is a constant. The effect of the wind was allowed for by varying the value of C . Later workers have usually introduced a factor of the form $(1 + kw)$ to allow for the wind speed w . According to the formula thus modified, the rate of evaporation increases indefinitely with increase of wind, whereas in practice a maximum value is obtained when the wind velocity reaches 15 to 20 miles an hour, and above this there is no further increase. The author, therefore, prefers to allow for wind by the introduction of an exponential factor, and deduces the equation,

$$E = C[(2 - e^{-kw})V - v].$$

Values of the coefficient $(2 - e^{-kw})$ may be read off from a graph thus simplifying the working. The formula is also applicable to the case of condensation. It will be seen that under certain conditions of temperature and humidity condensation will take place in still air, while there will be slight evaporation under the same conditions in a wind. This result has been verified in practice. The formula as stated applies to a small liquid surface. The latter part of the paper is devoted to a consideration of the case of a larger area where the evaporation from the leeward part will be hindered by the presence of the vapor given off by the part more to windward. The author states that it will, in many cases, be more accurate to calculate the rate of evaporation from a large water surface by means of the formulæ here put forward, than to rely on attempts at direct measurement with the ordinary type of evaporimeter.—J. S. Di[nes].

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FORESTS-AND-RAINFALL EXPERIMENTS.

There appeared in *Nature*, for August 2, 1917 (pp. 445-446), a review by Mr. Hugh R. Mill, of the recent

Indian Forest Bulletin No. 33 by M. Hill, chief commissioner of forests of the Central Provinces. Dr. Gilbert Walker of the Indian Meteorological Department contributed two appendices to that bulletin, and concerning Dr. Walker's conclusions Mr. Mill says in part:

Dr. Walker considers that, as Blandford pointed out in 1887, "the only satisfactory evidence would be that obtained by comparing the rainfall of a district when well supplied with forests with that of the same district when the trees were very few." In our opinion the comparison should not be that of a district A at the time t with the same district at the time t' ; but to compare the relation of district A to a contiguous district B at the time t with the relation of A to B at time t' , where A is a district that has undergone a great change as regards forest covering, while B has remained unchanged. The reason for this indirect comparison is, of course, to eliminate the effect of the two periods falling in what Prof. H. H. Turner calls different climatic chapters. Another method would be to determine the relation of the isohyetal lines to the configuration of the land on wooded and treeless districts of similar character. As pointed out in the report on the rainfall in the Geological Survey's "Water Supply Memoirs of Hampshire," the district of the New Forest shows a considerably higher general rainfall than its elevation above sea level appears to suggest. The subject is both fascinating and important, and the time will no doubt come when increase of accurate observations will enable the vague belief in the beneficial influence of forests on climate to be supported or corrected by definite meteorological evidence.

It seems appropriate here to recall the circumstance that precisely the first method here suggested by Mr. Mill for solving the problem of the relations between rainfall and forestation was adopted by the United States Weather Bureau in 1910, cooperating with the United States Forest Service. These two services have selected two contiguous and practically identical watersheds in the Rio Grande National Forest (lat. $37^{\circ} 45' N.$, long. $106^{\circ} 50' W.$, alt. 9,400-11,000 feet) near Wagon Wheel Gap station on the Denver & Rio Grande Railroad, at present under identical forested conditions, and have established therein a large number of thermometer, precipitation, and stream-gage stations. Careful observations will be carried on in both watersheds for a number of years¹ and at the conclusion of this first period one of the watersheds will be deforested and the same observations continued for a second period corresponding to the first one.

Already we have secured nearly a full 6-years' record there, as observations actually began October 22, 1910. While the United States seems to have been the first to take this step, it is certainly desirable that as many other countries as possible should make the same test.

Concerning the second method suggested by Mr. Mill, it is not likely that any area in the United States is sufficiently supplied with well-distributed raingages to encourage one in undertaking the computational labor involved.—C. A., jr.

EXCESSIVE PRECIPITATION IN LONDON, ENGLAND.

[Reprinted from *Nature*, London, June 21, 1917, 99:328.]

Dr. H. R. Mill records, in the *London Times* of June 19, 1917, that the thunderstorm between 5 and 7 p. m. (summer time)² on Saturday, June 16, was, if measured by rainfall, one of the most severe ever experienced in London. More than 2 inches fell over an area measuring 10 miles from Barnes to Finsbury Park and 4 miles from Hyde Park to Willesden Green. At two points within this area more than 3 inches was reported—viz,

¹ The experiment is described in detail in the MONTHLY WEATHER REVIEW, September, 1910, 38:1453-1455, with map.

² "Summer Time." This is the first reference in the MONTHLY WEATHER REVIEW to the "daylight saving" scheme that has been in such general use among European countries since 1916. "Summer time" in England is 1 hour faster than Greenwich Mean Time. A presentation of the advantages and disadvantages of "Summer Time", as developed by a year of actual experience therewith, will be found in Review of Reviews, New York, June, 1916, pp. 715-716.—C. A., jr.

¹ Engineering News-Record, New York, Apr. 26, 1917, 78:196-199.